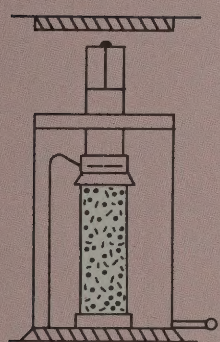
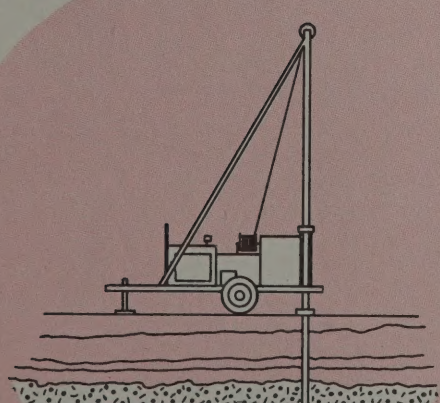
STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION

SOIL MECHANICS
BUREAU





STATE OF THE PRACTICE REVIEW

INSTALLATION OF UNCASED GAS AND HAZARDOUS LIQUID TRANSMISSION PIPELINE CROSSINGS UNDER NEW YORK STATE HIGHWAYS

SM 238b (1/73)

STATE OF THE PRACTICE REVIEW:
INSTALLATION OF UNCASED GAS AND HAZARDOUS LIQUID TRANSMISSION PIPELINE CROSSINGS UNDER NEW YORK STATE HIGHWAYS

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I. PURPOSE

The purpose of this investigation is to determine whether the New York State Department of Transportation preference for encasement of high pressure gas and hazardous liquid transmission pipelines crossing under state highways is necessary and appropriate. This investigation is based upon federal and state regulations, professional organization policies and guides, available research results, accident investigations, and practices in use by other similar agencies. For the purposes of this report, high pressure shall mean operating pressures exceeding 200 psi.

This investigation is not intended to address or be applied to the encasement of water, sewer or any other utilities crossing under state highways. The risks and problems associated with other utilities are entirely different than those presented here.

II. BACKGROUND

Buried pipelines have been used to carry gas and hazardous liquid in the United States for more than 50 years. Early pipelines were typically constructed of uncoated or asphalt coated cast iron pipe using bolted, bell and spigot or other mechanical type joints. These early pipelines lacked the strength to withstand induced loads from road and/or rail traffic above the buried pipe. Casings under highway crossings allowed the insertion of the carrier under the roadway without damage to the joints. Advances in metallurgy and manufacturing processes as well as improved construction techniques have produced pipelines today that are far superior to those early pipelines.

A typical transmission pipeline today is constructed of high strength, epoxy coated steel carrier pipe which is joined using full penetration welding techniques. The term "carrier pipe" refers to the pipe that carries the product, and the term "casing" refers to a separate, larger pipe that is in some cases installed in the ground, and the carrier inserted into it. Figure 1 illustrates typical installations and further identifies some of the terms to be used in this report. Plastic pipelines are limited by USDOT to 100psi, and therefore will not be discussed here.

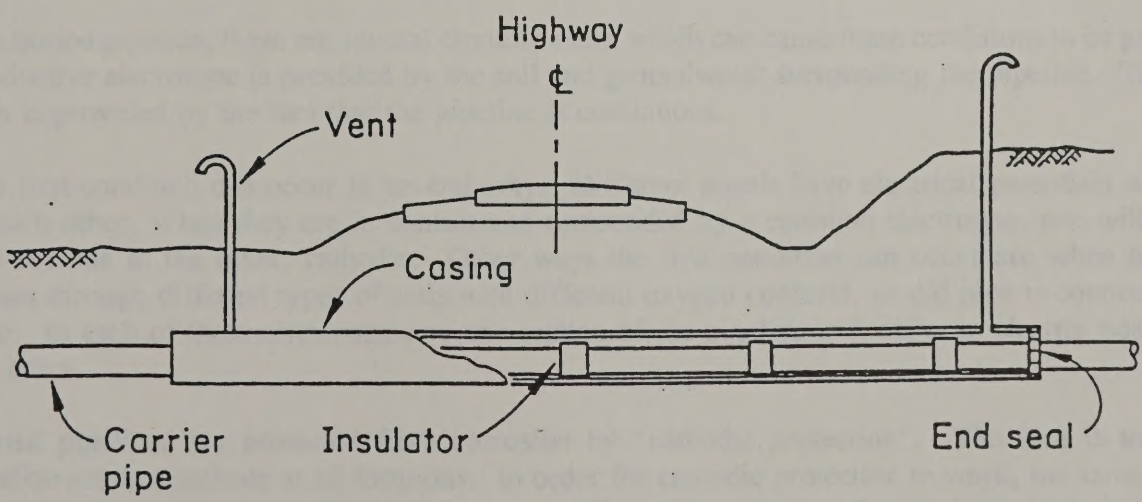

Figure 1. Typical Cased Pipeline Crossing at a Highway

Natural gas is an explosive, odorless and colorless gas which is lighter than air. Chemical odor- causing additives are typically added by transmission or distribution companies to aid in leak detection. Natural gas is typically transported from the production point within a transmission pipeline at pressures of 200 to 1200 psi. The pressurization process for natural gas typically occurs at widely spaced compressor stations, increasing the temperature immediately downstream of the station to approximately 80 to 140 degrees.

Propane is an explosive gas that is heavier than air. Propane is typically stored and transported in a compressed liquid state and vaporizes into a white mist upon release to the atmosphere. Because it is heavier than air and will flow across the ground and collect in low points, propane is particularly hazardous.

Kerosene, gasoline and other liquid petroleum products are typically transported at much lower pressures than gaseous materials due to the relative incompressibility of liquids. These liquids are often extremely flammable and pose a much greater and longer lasting environmental threat to surrounding communities than gas products.

CORROSION

Corrosion can be thought of as the movement of electrical current. At points where current discharges from a metallic structure, it takes metal with it. This is where corrosion will occur. The conditions which must be present for a corrosion cell to operate are as follows:

> There must be an anode (current discharges-material corrodes) and a cathode (current enters-material does not corrode) with an electrical potential between them.
>
> There must be a metallic path connecting the anode and cathode.
>
> The anode and cathode must be immersed in an electrically conductive electrolyte.

In a buried pipeline, there are several circumstances which can cause these conditions to be present. The conductive electrolyte is provided by the soil and groundwater surrounding the pipeline. The metallic path is provided by the fact that the pipeline is continuous.

The first condition can occur in several ways. Different metals have electrical potentials with respect to each other. When they are in contact and surrounded by a common electrolyte, one will be anodic and corrode to the other, cathodic. Other ways the first condition can occur are when the pipeline passes through different types of soils with different oxygen contents, or old pipe is connected to new pipe. In each of these circumstances, one section of the pipeline will differ in electric potential from the other.

Buried pipelines are protected from corrosion by "cathodic protection". The idea is to make the pipeline act as a cathode at all locations. In order for cathodic protection to work, the same conditions necessary for a corrosion cell must be present. Cathodic protection does not eliminate corrosion, but rather transfers it to a known and controlled location.

Natural gas is an explosive, odorless and colorless gas which is lighter than air. Chemical odor causing additives are typically added by the operators of distribution companies to aid in leak detection. Natural gas is typically transported from the production point within a transmission pipeline at pressures of 200 to 1200 psi. The compression process for natural gas typically occurs at widely spaced compressor stations, increasing the gas temperature immediately downstream of the station to approximately 90 to 130 degrees.

Propane is an explosive gas that is heavier than air. Propane is typically stored and transported as a compressed liquid and will vaporize into a gas when released to the atmosphere. Because it is heavier than air and will flow toward the ground and collect in low points, propane is particularly hazardous.

Kerosene, gasoline and other liquid petroleum products are typically transported at much lower pressures than gaseous materials due to the noncompressible nature of liquids. Large liquids are often extremely flammable and pose a much greater fuel supply, or any environmental threat to surrounding communities than gas products.

CORROSION

Corrosion can be thought of as the movement of electrical current. At points where current leaves (or flows from) a metallic structure, it takes metal with it. That is, where corrosion will occur. The conditions which must be present for a corrosion cell to operate are as follows:

There must be an anode (current discharge) area and a cathode (current collection) area which are connected with an electrical path between them.

There must be a metallic path connecting the anode and cathode.

The anode and cathode must be immersed in an electrically conductive electrolyte.

In a buried pipeline, there are several circumstances which can cause these conditions to be present. The conductive electrolyte is provided by the soil and groundwater surrounding the pipeline. The metallic path is provided by the fact that the pipeline is continuous.

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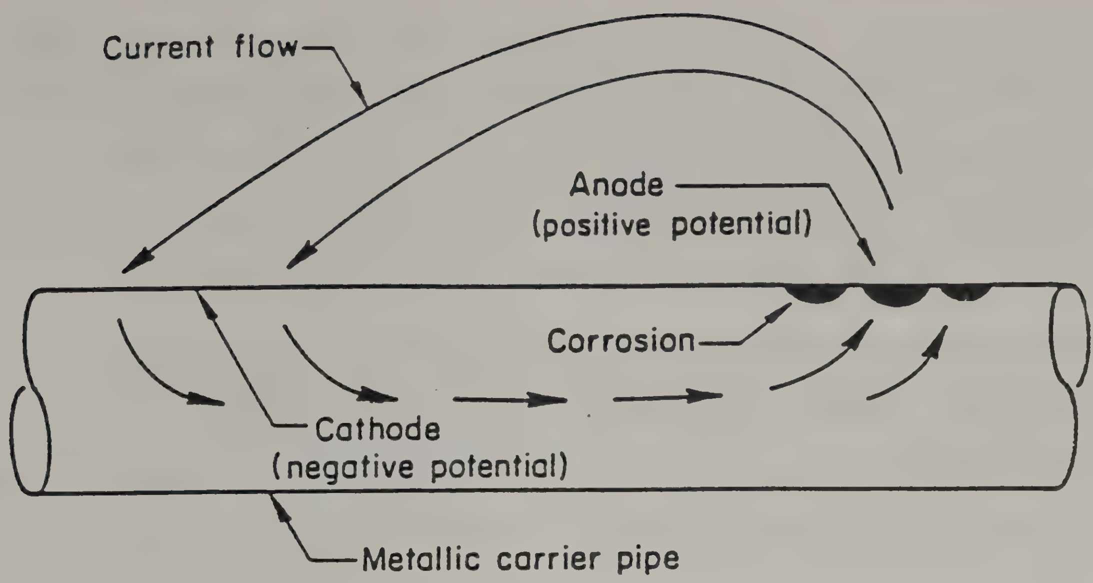

Figure 2. Corrosion and Associated Current Flow due to Potential Differences Along an Underground Pipeline.

CATHODIC PROTECTION

A cathodic protection system is required for a transmission pipeline by the USDOT Office of Pipeline Safety as outlined in 49 CFR Part 192, Subpart I. There are two types of cathodic protection systems, impressed current and sacrificial anode.

An impressed current system consists of an AC current source (electric distribution system), a rectifier (converts AC to DC), an anode bed and a return path (ground) from the pipeline to the rectifier. A current is induced from the rectifier to the ground bed, then through the soil toward and onto the pipeline. This current flow is in the opposite direction to the current that naturally occurs between anodic sections of a pipeline and the soil. It is this reversal of the current (electron) flow that prevents corrosion of the pipeline. This system uses a larger current (electron) flow than a sacrificial anode system to protect many miles of pipeline from a single rectifier. A rectifier system is often preferred for the protection of a large interstate pipeline.

A sacrificial anode system relies on the natural electric potentials of dissimilar metals rather than artificially "impressing" current. This system consists of a larger number of sacrificial anodes than found in an impressed current system. These anodes are also connected to the pipeline at closer intervals (measured in hundreds of feet). Sacrificial anodes may also be placed in banks of 5 to 20, at 20 to 30 feet spacings, with 1,000 to 5,000 feet between banks. The anodes consist of a material such as zinc or magnesium that is naturally anodic to (having a lower electric potential than) the steel in the pipeline.

Both of these types of cathodic protection systems force current onto the pipeline at all locations where steel is exposed to the soil. Modern pipelines are installed with coatings over the steel. If the coatings were 100% perfect, the impressed current or sacrificial anodes would not be necessary. A properly selected and applied coating should be better than 99% effective. Bare steel pipelines could be protected but would require much more current than a coated pipeline. The function of a corrosion engineer is to design a cathodic protection system that best combines pipeline coatings and current sources to economically achieve a cathodically protected state with the desired design life.

In locations where buried pipelines run parallel to or under overhead high voltage electric transmission lines, the pipe picks up electrical charge, known as "step and touch" voltage. This difference between the potential of the pipe and soil can cause a shock if someone touches the pipe. A thin (1/4") zinc ribbon is often installed in the same trench as the pipeline. This ribbon serves dual purposes, zinc is anodic to steel and functions as the cathodic protection system, and the zinc ribbon also drains current from the pipe and raises the potential of the surrounding soil, reducing the "step and touch" voltage. The industry standard is to limit this difference to 15 volts at locations where a person could touch the pipe.

The dimensions and details of systems listed above should be considered illustrative only, and are not intended to be design guidelines. There are many other factors which must be considered in determining the number, size and interval of anode installations, including amount of steel to be protected, effectiveness of the coating, and soil resistivities.

The presence of a casing has proven to be a major obstacle to the successful operation of a cathodic protection system. The casing eliminates one of the conditions necessary for a cathodic protection system, the electrolyte (soil) surrounding the carrier pipe. The absence of the electrolyte prevents protective current from reaching the carrier pipe. This also eliminates one of the conditions necessary for a corrosion cell. If the carrier pipe remains perfectly isolated from the casing pipe, and no electrolyte (soil or water) gets into the annular space, there is no corrosive environment. However, this is often not the case a few years after installation. Contact between the carrier and casing pipe (electrical short) can occur due to uneven settlement. Insulating spacers can be crushed or they may have been bunched up at one end during installation. Water can collect in the annular space between the casing and carrier due to condensation of air that enters through the vent piping. The installation of casing seals is designed to keep water out of this space, but it is not always effective.

If contact between the carrier and casing occurs, the casing pipe acts as a very large area of bare steel, drawing a large amount of cathodic protection current away from the carrier pipe outside the casing and causing the anodes to deplete rapidly.

Another potentially corrosive condition exists when an electrolyte (water or soil) enters the annular space between the casing and carrier pipes. If the annular space is filled, and remains filled with groundwater, the cathodic protection system will continue to function because the protective current will flow through the casing pipe and the electrolyte to the carrier pipe. However, "If the groundwater level fluctuates, the alternating wetting and drying at the oxygen–rich interface of exposed steel and the fluctuating electrolyte level can result in severe atmospheric corrosion attack." (GRI–88/0287)

Atmospheric corrosion can be easily overlooked or underestimated as a cause for concern on a buried pipeline. Atmospheric corrosion, upon careful examination, can be identified as a threat to pipeline integrity and safety. A buried pipeline becomes exposed to atmospheric corrosion when vents are installed on the ends of casing pipes at highway or railroad crossings. Vents allow the accumulation of moisture within the annular space under certain atmospheric conditions. A buried pipeline operating at a lower than atmospheric temperature will form condensation on its surface within the casing, which promotes corrosion.

If both conditions exist, a metal–to–metal electrical short and an electrolyte in the annular space, cathodic protection current will flow along the casing pipe to the point of contact with the carrier. The current will take this path instead of through the electrolyte to the carrier because the casing pipe provides a lower resistance path. Current would not be going to the carrier pipe inside the casing in contact with the electrolyte. instead, current would tend to discharge from the carrier pipe onto the inside of the casing pipe, i.e. the carrier would corrode.

Placement of dielectric (conductive) electrolyte in the annular space is sometimes used as a method of keeping the carrier pipe and casing electrically connected and all points on the carrier pipe in contact with an electrolyte – a necessary condition for effective cathodic protection. The dielectric material is a waxy, petroleum–based material. Failure of the casing or the end seals may result in release of the dielectric to the environment, which is an environmental hazard. This is a realistic possibility in this design because current is discharging on the inside of the casing pipe as it enters the electrolyte. A corrosion leak eventually forms from the inside of the casing outward. Filling the annular space with a dielectric material is sometimes done to correct a shorted condition. This remedy is preferable to a shorted casing, but should not be considered a preferred design method for a new cased installation.

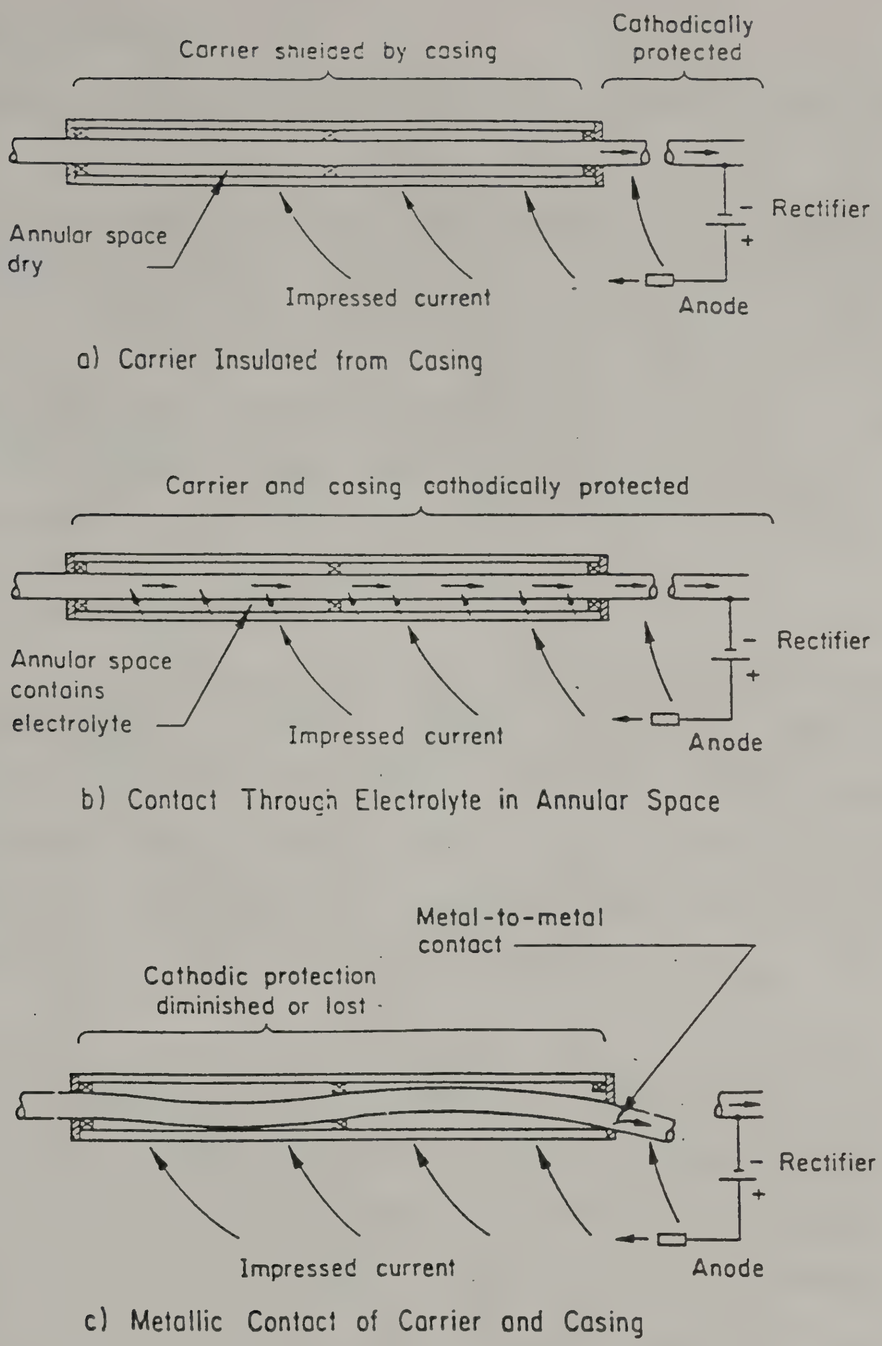

Figure 3. Effects of Casing Conditions on Cathodic Protection

INSPECTION

The primary method of inspection of pipeline for corrosion damage is through the monitoring of pipe-to-soil electrical potential, which is required under Title 16 to be conducted annually, at intervals of not more than 15 months. The presence of a casing prevents the effective evaluation of the pipeline integrity through the use of pipe-to-soil electrical potential measurements. Visual inspection of carrier pipes for damage due to corrosion is prevented by the presence of a casing under a highway crossing, as well as the presence of the highway itself.

III. STATE OF THE PRACTICE

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO has historically been the source of much of the valuable published research and guidelines relative to highway design and construction. Three separate AASHTO publications directly influence the encasement issue. The first is "A Policy on the Accommodation of Utilities on Freeway Rights–of–Way", 1969 and 1982. The second is "A Guide for Accommodating Utilities Within Highway Rights–of–Way", 1969 and 1981. There is no substantial difference between the original and revised version of either of these two documents as they relate to encasement of pipelines. The third publication is "A Policy on Geometric Design of Highways and Streets", 1984, 1990. None of these publications makes any specific recommendation on the use of casings, but rather states that while an arbitrary requirement for casings may be unnecessarily expensive, it is not wise to waive casing requirements in all cases.

FEDERAL HIGHWAY ADMINISTRATION

The Federal Highway Administration (FHWA) has adopted, in succession, the AASHTO publications "A Policy on the Accommodation of Utilities on Freeway Rights–of–Way" and "A Guide for Accommodating Utilities Within Highway Rights–of–Way". The historic position of the FHWA was to strongly recommend encasement of natural gas pipelines crossing highways. FHWA has benefitted from experience and input from state highway agencies, as well as from pipeline companies, and consequently its position has evolved with the introduction of new technologies and successful practices. FHWA currently has no written policy on the encasement of natural gas pipelines under highway crossings, and no longer recommends the use of casings, but rather defers to state highway agencies to follow practices which are appropriate to the prevailing local conditions, practices and regulations.

FHWA allows absolutely no cutting of pavement on interstate highways for the purpose of installing utilities and continues to encourage the use of casings under interstate highways. The FHWA recommendation for the use of casings under interstate highways is due to technical constraints on installation. The crossing of an interstate highway is typically much longer, often by an order of magnitude, then the crossing of a two lane state highway. The design of a crossing under an interstate highway is often controlled by the allowable pipe stresses induced during the installation process, whether it be jacking or tunneling. For this reason, casings are sometimes required under interstate highways in areas where they are not required elsewhere. A more advanced trenchless technique, such as horizontal directional drilling, would remove most of the technical constraints associated with a longer crossing, but has limitations of its own.

NATIONAL TRANSPORTATION SAFETY BOARD

A total of five accidents involving transmission pipelines were reviewed in accident investigation reports published by the National Transportation Safety Board (NTSB). Not all accidents or problems are reviewed by the NTSB, but the list is an indicator of serious problems. Of the five pertinent accidents reviewed, four occurred inside a casing at a highway crossing and the fifth occurred at a point within 30 feet of a casing at a highway crossing. A brief review of each accident is found in Appendix A.

TRANSPORTATION RESEARCH BOARD - NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

The Transportation Research Board, through the National Cooperative Highway Research Program (NCHRP) has funded several investigations into the issue of encasement of natural gas pipelines crossing under highways. Two of the most important and relevant publications by NCHRP are "Encasement of Pipelines Through Highway Roadbeds", 1983 and "Protection of Pipelines Through Highway Roadbeds", NCHRP Report 309, July 1988. These reports summarize the requirements of many international, national and state agencies, and also present the positions of many pipeline operators and utilities. The summary of findings in NCHRP Report 309 states "Each crossing should be evaluated as the unique situation that it is. All methods available to provide protection, including the use of casing pipes, should be considered."

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The American Society of Mechanical Engineers (ASME) publishes An American National Standard Code for Pressure Piping, which is accredited by the American National Standard Institute (ANSI). The two pertinent codes are B31.8-1982 and B31.4-1979, which deal with gas and liquid petroleum piping systems, respectively. ASME/ANSI B31.8-1982 states:

> "862.117 Casings. The use of metallic casings should be avoided insofar as possible from a corrosion control standpoint. However, it is recognized that installation of metallic casings is frequently required or desirable to facilitate construction, as an economical method of protecting existing pipelines, to provide structural protection from heavy or impact loads, or both, to facilitate replacement as required by government agency and as required by the landowner or permit grantor, and for other reasons...."

NEW YORK STATE PUBLIC SERVICE COMMISSION

The New York State Codes, Rules and Regulations (NYCRR), Title 16, Department of Public Service, Part 255 governs the transmission and distribution of gas. This regulation correspond directly to the Code of Federal Regulations, Title 49, Part 192. NYCRR 16 §255.105 requires that all uncased installations use a reduced design factor (F). This reduced design factor would correspond to a more densely populated area for a cased installation. The design factor reduction results in a more conservatively designed carrier pipe in the case of an uncased crossing than if a casing had been used.

NEW YORK STATE DEPARTMENT OF TRANSPORTATION

The New York State Codes, Rules and Regulations (NYCRR), Title 17, Department of Transportation, Part 131 governs the installation of underground utilities within the state highway right–of–way. NYCRR 17 §131.17 states "Underground work shall be in accordance with the AASHTO Guide" and "Crossover carrier pipes shall be encased ... or made stronger and more durable ... by a method satisfactory to the department" [of Transportation]. The "Requirements for the Design and Construction of Underground Utilities Within the State Highway Right of Way", Revised January 1988 states "4.02.03 Uncased crossover carrier pipes are generally not allowed, ..." The AASHTO Guide, which is included as Appendix A–9 to Title 17, specifically states that an arbitrary requirement for casings is unnecessary. Part 131 is under revision to remove any wording that indicates a preference for cased crossings.

The New York State Department of Transportation has a legislative mandate to provide effective and economical transportation services while maintaining public safety. The requirement for gas and hazardous liquid pipeline companies to provide encasement of pipelines crossing state highways has historically provided additional protection to the pipeline from loads and stresses applied by the roadway and live loads due to traffic. In the past it has been incorrectly perceived that encasement provides protection to the roadway surface during installation, in that it helps prevent loss of ground and roadway settlement or movement.

OTHER STATE HIGHWAY AGENCIES

A number of state highway agencies around the country were contacted in order to canvass the positions of other responsible agencies on casing requirements. The concentration was on those agencies listed in the Gas Research Institute Report "State–of–the–Art Review: Practices For Pipeline Crossings at Highways" as requiring casings or with extensive experience with pipelines. Two states listed as requiring encasement of natural gas pipeline crossings of state highways no longer require encasement. Eighteen other states were listed as not requiring encasement, and the majority listed the alternatives outlined in NYCRR Title 17, Part 131 (thicker pipe wall, corrosion coating, concrete jackets, etc.) as methods of providing a safe crossing design. A review of the states contacted is found in Appendix B.

NATURAL GAS PIPELINE INDUSTRY

The natural gas pipeline industry has been advocating the use of uncased crossings for more than 30 years, since the advent of improved pipeline materials and construction methods. The industry claims that a blanket requirement for encasement is unnecessary and an impediment to the establishment of an effective cathodic protection system. They also claim that history has shown failures are far more likely to occur at a cased crossing than at an uncased one. While it is recognized that the primary motivator and goal of a gas pipeline company is the generation of revenues and profit, it must also be recognized that it is in the best interest of a pipeline company to install and operate a pipeline that will provide long term service and reliability with minimal maintenance. An interruption of service in a gas transmission line incurs the costs of repairs and at the same time reduces revenues. The historical experience of pipeline companies with state highway agencies requiring encasement may cause them to abandon the attempt to gain approval for uncased crossings if they feel the effort is futile.

GAS RESEARCH INSTITUTE

To help pipeline operators accomplish their goal of maintaining a pipeline safely and economically, the Gas Research Institute (GRI) has been liberally funded by the gas pipeline industry. The pipeline industry would prefer, where appropriate, to install uncased pipeline crossings under highways, with a continuous cathodic protection system as required by USDOT mandate. The GRI Report "State of the Art Review: Practices for Pipeline Crossings at Highways", 1988, states, "Except for emergencies, removal of carrier pipes from casings for repairs has proven to be impractical for many natural gas systems."

RAILROADS

All the responses to the NCHRP Report "Encasement of Pipelines Through Highway Roadbeds" from railroads cite the same reference, the American Railway Engineering Association (AREA) Manual, Chapter 1, Part 5. The following quote from the NCHRP Report is indicative of the response "But it is certainly not worth risking the lives of the general public, railroad employees, and railroad passengers to find out how dangerous the elimination of casing would be."

In March 1993, revisions to the AREA Manual were approved, effective August 1993 with the printing of the annual revisions, allowing the use of uncased crossings. The manual addresses specific technical requirements for carrier pipe with regard to specified minimum yield strength (SMYS), allowable hoop stresses, allowable multiaxial stresses, and minimum depth of cover. The suggested methods to provide adequate pipe strength at an uncased crossing are basically the same suggested by AASHTO and NYCRR Title 17 for use at highway crossings.

IV. ISSUES AND EVALUATIONS

RAILROADS vs. HIGHWAYS

The installation of a natural gas pipeline under a railroad bed faces the same issues as the installation under a highway, with the addition of the issue of loading case. The E-80 loading condition induced by a passing train is far greater and includes far greater impact and vibratory loading than the heaviest load induced by highway traffic. The installation of an uncased pipeline under a railroad is limited by the ability of the available pipe section to resist both static and dynamic loadings. The design of any crossing under a railroad should address the effects of railroad electric power and signal systems on cathodic protection systems as well as the effects of a potentially corrosive environment due to the presence of cinders and/or slag, which are commonly encountered in or near a railroad embankment.

VENTS

The purpose of vent pipes raised to grade as stated in NYSDOT rules and regulations is to disperse liquid or vapors accumulated in a casing due to a leak in the carrier pipe. Carrier pipes operating at a pressure of approximately 1000 psi will not develop a "minor" or "pinhole" leak as evidenced by the failure in Beaumont, Kentucky. The accident investigation report concluded that the catastrophic failure occurred as a result of a reduction in wall thickness of approximately 65%. The reduction of the entire wall thickness in however small a hole would likely cause a similar catastrophic failure. Therefor, vent pipes raised to grade will not allow the dispersal of released gas from a leak, and only provide a path for transmission of atmospheric changes to the "sealed" environment inside the casing. The vents allow condensation to collect on the surface of the carrier pipe, and allow additional deterioration of the carrier pipe through atmospheric corrosion.

END SEALS

End seals are typically constructed of a plastic or rubber based material and are attached in place around the end of the casing pipe with metal bands. The problem lies in providing a friction seal around the surface of the carrier pipe, without attaching anything by means of welding or other similar method that could compromise carrier integrity, while resisting large lateral earth pressures and remaining flexible. Seals are often found not to be water tight.

CASING SPACERS

Spacers are typically placed around the carrier pipe within the casing in order to electrically isolate the carrier from the casing. Spacers are typically constructed of a plastic or rubber material. Problems occur during the insertion of the carrier pipe if the spacers bind or meet an obstruction in the casing. This can result in the spacers bunching together at some point or breaking, leaving the carrier vulnerable to short circuiting due to settlement of the casing rather than isolated as the design intended.

Some pipeline companies have attempted to reduce the deleterious effects of casing spacer problems by using a concrete cement coated carrier pipe within the casing as recommended in NYCRR 17 §131.17 d.1.iii. The cement concrete coating is approximately 1 inch thick which provides continuous abrasion protection for the corrosion-preventing epoxy during installation.

V. RISKS

The risks associated with dropping the blanket requirement for encasement of gas and hazardous liquid transmission pipelines under state highways can be separated into two categories, risks to pipeline integrity and risks to roadway serviceability. The body of evidence reviewed and presented indicates that encasement does not enhance pipeline safety. Roadway serviceability will not be adversely affected by a change in the encasement requirement. The installation of a casing presents nearly the same risk to roadway serviceability that installation of an uncased carrier pipe does, therefore issues concerning damage or decrease in roadway serviceability should be addressed through proper installation methods under the permitting process currently in place.

VI. CONCLUSIONS

The use of encasement to provide additional strength to resist induced dead loads from a highway embankment or live loads due to traffic is unnecessary for a typical high strength steel pipeline. The replacement of an existing pipeline placed in a casing will almost always include the installation of a new line in order to minimize disruption of service. The use of a casing does not guarantee in any manner that the installation will not result in damage to the roadway riding surface. The encasement of a carrier pipe has potentially serious negative impacts on the cathodic protection system required of all new pipelines in this category. Settlement of the carrier pipe outside the casing may cause longitudinal bending stresses. The installation of vents on casing pipes exposes the carrier pipe to atmospheric corrosion processes which would not be present in a buried pipeline.

The current state of practice and the evidence available clearly indicate that a blanket policy requiring or recommending the encasement of all highway crossings by gas or hazardous liquid pipelines is unnecessary and may not be in the best interest of public safety. The currently available pipe materials; fabrication, installation and inspection techniques; and improved design methodologies allow uncased crossings to provide adequate assurance of public safety without encasement. Current installation techniques provide an amount of protection to the roadway using only the carrier pipe similar to that using a cased crossing, without risking failed cathodic protection and increased corrosion of the pipeline caused by the presence of a casing.

The New York State Department of Transportation does not have the resources, particularly in the Regional Offices, to adequately review pipeline design. The New York State Public Service Commission is best qualified to conduct the review of pipeline design with regard to operating pressures, specified minimum yield strength (SMYS), pipe material requirements and cathodic protection systems.

VII. RECOMMENDATIONS

Based on this investigation, it is recommended that the New York State Department of Transportation revise the New York State Codes, Rules and Regulations, Title 17, Part 131 and its "Requirements for the Design and Construction of Underground Utilities Within the State Highway Right of Way", Revised January 1988, and delete any preference for encasement of high pressure gas and hazardous liquid transmission pipeline crossings of state highways. Most crossings of state highways by gas or hazardous liquid pipelines can be safely designed and installed without the use of a casing. Each crossing should be evaluated on an individual basis to determine whether encasement is appropriate or not. All permits issued by the Department of Transportation for pipeline crossings under New York State highways should be conditional upon Public Service Commission review and approval. Formal notification of the Department of Transportation of Public Service Commission approval should be the responsibility of the applicant.

APPENDICES

Appendix A - NTSB Accident Report Reviews

Appendix B - Review of Contacts with State Highway Agencies

Appendix C - References

Appendix A

NTSB Accident Report Reviews

Monroe, Louisiana Accident
On March 2, 1974 a 30 inch steel natural gas transmission pipeline constructed in 1956 failed inside a 34 inch steel casing. Escaping gas filled the annular space and exploded, creating a trench 100 feet long, 30 feet wide and 25 feet deep.

A substandard girth weld failed due to unrestrained flexure inside the casing caused by soil settlement outside the casing. NTSB concluded "If carrier pipe with heavier walls had been installed at this road crossing instead of casing pipe, this failure might not have occurred" and recommended that an industry-wide survey on the value of casing pipelines beneath railways and highways be conducted.

Mannassas, Virginia Accident
On March 6, 1980 a 32 inch steel refined petroleum products transmission pipeline constructed in 1963 failed inside a 40 inch steel casing. Approximately 336,000 gallons of aviation-grade kerosene were released into the environment, contaminating water supplies and wildlife refuges.

The failure occurred at a location within a casing thinned by galvanic corrosion. The corrosion was caused by exposure of the carrier at a location where the protective coating had been damaged during installation in the casing. Groundwater had penetrated the annular space between the carrier and the casing, causing an electrolytic short circuit.

Beaumont, Kentucky Accident
On April 27, 1985 a 30 inch steel natural gas transmission pipeline constructed in 1952 failed inside a 36 inch steel casing. Escaping gas at a gage pressure of 992 psi exploded, creating a crater across State Highway 90 that was 90 feet long, 38 feet wide and 12 feet deep. Five deaths and three injuries resulted.

The failure occurred at a point where the wall thickness had been reduced to 35% of the original due to atmospheric corrosion within a casing. Resistance measurements and potential shift cathodic surveys failed to detect the problem, particularly in the area of the crossing where the carrier was shielded from cathodic protection by the casing pipe.

Lancaster, Kentucky Accident
On February 21, 1986 a 30 inch steel natural gas transmission pipeline constructed in 1957 and operating at 987 psi failed 30 feet south of the casing pipe under State Highway 52. The explosion tore 480 feet of pipeline out of the ground and created a crater 500 feet long, 30 feet wide and 6 feet deep. Eight personal injuries resulted from the incident. The presence of a large rock formation shielded the pipeline from the cathodic protection system. After the accident at Beaumont, Kentucky the year before (which involved the same pipeline company), the owner had begun an intensive corrosion monitoring program involving an in-line survey. The corroded area was excavated and inspected, but the company failed to establish guidelines under which badly corroded areas would be identified and repaired immediately.

North Blenheim, New York Accident

On March 13, 1990 an 8 inch steel liquid propane gas transmission pipeline constructed in 1964 failed inside a 12 inch steel casing. Escaping propane gas vaporized, flowed downhill and exploded. Two deaths and seven injuries resulted.

The failure occurred within a casing due to stress fractures induced by the attempted repair of a shorted casing. As a part of the repair procedure, the carrier was excavated and exposed for approximately 70 feet immediately adjacent to the casing. The carrier was raised several inches in order to replace a broken spacer and end seal and correct a short circuit due to physical contact between the carrier and the casing. The repair was completed and the excavation backfilled. Three weeks later the carrier pipe ruptured and subsequently exploded.

Appendix B

Review of Contacts with State Highway Agencies

A brief summary of telephone conversations with representatives of each of the states contacted is presented below.

CALIFORNIA

Mr. Charles Howard, Right of Way Engineering and Utilities Branch, California Department of Transportation (CalDOT), indicated that there were no recommended design alternatives to encasement of natural gas pipelines in California. However, each proposal and request for a permit is reviewed by CalDOT on a case-by-case basis. The Chief, Utilities Branch accepts recommendations and comments from department personnel on the proposal, and then issues a decision based on his authority alone. This review has been, in the recent past, a vehicle for the acceptance by CalDOT of a large number of uncased crossings of pipelines under highways.

KENTUCKY

Mr. Donald Werner, State Utilities Engineer, Division of Right of Way/Utilities, Kentucky Department of Highways (KDOH), stated that no encasement was required for natural gas transmission pipelines crossing existing state highways. KDOH does require the installation of casings under new highways when a pipeline location is already determined at the time of construction. This is designed to prevent damage to the riding surface during installation of the carrier. KDOH has perhaps the most experience of any state agency in the United States, as a result of three catastrophic failures and explosions in Kentucky in recent years. Each failure resulted in substantial property loss and two resulted in loss of life.

MAINE

Mr. John Hicks, Utilities Engineer, Maine Department of Transportation, stated that they had very limited experience with natural gas pipelines, as there were a total of only three transmission lines of any kind in the state. Mr. Hicks stated that their policy was not to require encasement of highway crossings, except under an Interstate Highway. He was unsure as to where the requirement had originated, but felt that it was probably originally instituted by the Federal Highway Administration.

MARYLAND

Mr. Joseph Bissett, Chief, Utilities Section, Office of Construction, Maryland State Highway Administration (MSHA), is responsible for policy regarding utility crossings of state highways. He stated that previously no alternatives were permitted for encasement of natural gas pipeline crossings of Maryland state highways. However, his predecessor, Mr. Roland Rushworth, instituted a change to the long standing policy, somewhat reluctantly, when presented with extensive material and research supporting the gas pipeline industry's position. Since that time, MSHA has allowed consultants to submit technical proposals for in-house review, and has allowed uncased crossings of state highways when appropriate design alternatives are presented.

MASSACHUSETTS

Mr. Steve O'Donnell, Utilities Section, Massachusetts Department of Public Works (MassDPW) stated that it was their policy to require encasement of all natural gas pipelines crossing a state highway. In addition MassDPW requires that no natural gas pipeline be installed under a controlled access highway, but that rather all such pipelines cross the highway overhead at the nearest structure. This position is unique as far as can be determined. This information was refuted by Mr. Phillip Wells, Field Engineer, Boston Gas Company, in a conversation with the author at the ASCE Seminar "Trenchless Installation of Underground Utilities" in New York City on May 5-6, 1992. He stated that there were several natural gas transmission pipelines in his area running under I-495 and Route 2 west of Boston.

VIRGINIA

Mr. James Marston, Utilities Division, Virginia Department of Transportation (VaDOT) stated that VaDOT had changed its policy to no longer require encasement of all natural gas pipelines under state highways in the 1987/1988 time frame. The change in policy was prompted by a request from Commonwealth Gas Company, which provided substantial evidence to support their position that encasement was not necessary. VaDOT currently reviews all requests for installation of natural gas pipelines under state highways on a case-by-case basis at the residency level. Guidance and/or additional expertise is available from their main office, much like the system currently in place here in New York. VaDOT still requires the encasement of natural gas pipelines under Interstate Highways, in situations where adequate cover over the pipe is not available, in situations where difficulties with installation have the potential to damage the carrier pipe, and in situations where the installation methods for uncased crossings are not appropriate.

Appendix C

References

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